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ORIGINAL PAPER

"Terrae motus factus est": earthquakes in Switzerland before A.D. 1000. A critical approach

Monika Gisler · Donat Fäh · Virgilio Masciadri

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Abstract We focus on Swiss earthquakes in antiquity and the early medieval period before A.D. 1000. We have information on less than half a dozen earthquakes within this era, since written records for the first half of the first millennium A.D. are minimal, and there is little hope of finding more written evidence for earthquakes. Furthermore, interpreting the documents at hand is somewhat complex. For the 6th century *Gregory of Tours* in *Historia Francorum* gives hints of a rockslide near the castle *Tauredunum* (*Le Grammont*) in the Swiss canton Valais, an event that has been considered in the literature as caused by an earthquake. The *Carolingian* period (ca. 750–950) included the rise of some very important cultural centers in various parts of today's Switzerland. For instance, the ecclesiastical culture in St. Gallen generated a remarkable number of written records, which survived for our use in a unique manner. From the 9th and 10th centuries, we have evidence for earthquakes in the years 849, 867, 902, and 944. However, information on them remains so scarce that their location and intensity are generally difficult to assess. Nevertheless, the finding of a new document - a memoir written by the abbot of Reichenau - offers some insight into the A.D. 849 event and its reportedly aftershocks.

Keywords Earthquakes · Rockslide · Switzerland · Annals · (Early) Medieval period

1 Introduction

Earthquake recurrence intervals are important input data in seismic hazard assessment, but are often poorly constrained. In areas with a low deformation rate, such as

M. Gisler (✉) · D. Fäh
ETH Zurich, Swiss Seismological Service, HPP L5,
CH-8093 Zurich, Switzerland
e-mail: gisler@sed.ethz.ch

V. Masciadri
University of Zurich, Klassisch-Philologisches Seminar,
CH-8001 Zurich, Switzerland

intraplate regions, the recurrence intervals of strong earthquakes largely exceed the time span covered by instrumental measurements. Historical earthquake data therefore represent very basic information on long-term seismicity. The study of historical records attempts the reconstruction of past earthquakes to define the seismic hazards of a particular area.

The most extensive effort for the time period before A.D. 1000 comes from the INGV (Istituto Nazionale di Geofisica e Vulcanologia), which has provided studies on earthquakes and tsunamis in the Mediterranean area up to the 10th century (Boschi et al. 1997, 2000; Guidoboni 1989; Guidoboni et al. 1994). Switzerland has been included only marginally. The Belgian historian Alexandre (1990), on the other hand, presented a catalog for ancient and medieval seismicity in Western Europe, including Switzerland. This study provides relevant facts on the respective events, but lacks information on what debate surrounded the historical records. The Earthquake Catalog of Switzerland (http://www.seismo.ethz.ch) spans a time period of more than 1,000 years, with a preponderance of data from early modern and modern times (Fäh et al. 2003). Data come from macroseismic input largely, since reliable instrumental data is available since 1975 only. The time period before the year 1000 covers a small number of earthquakes though, since written evidence is small for this epoch. A potential earthquake of A.D. 250 in the Roman town of *Augusta Raurica* east of Basel relies on archeological evidence only, no written sources exist for this event (Fäh et al. 2006).

As we will argue in this paper, interpreting historical information to determine macroseismic data is far from unambiguous. This is particularly the case for the first millennium A.D. The most important source type for this period exists as narrative texts. The most comprehensive record was composed by Gregory of Tours (538/539–594), the *Decem Libri Historiarum (''ten books of History'')*, a chronicle of the Merovingian dynasty, being produced during Gregory's incumbency as Bishop of Tours in the years 573 through 593/94. Second is a chronicle by Marius (530/531–594), bishop of Avenches and a contemporary of Gregory (Marius d'Avenches 1991). The record is a continuation of the chronicle of Prosper for the years 455 through 581. Both chronicles contain information on earthquakes, even though not for the region of interest. One single narrative source exists for the 7th century (providing information for the years 584–642); it is the so called chronicle of *Fredegar*, mentioning natural disasters, however not considering seismic phenomena (Fredegar 1888).[1] The most prolific source type for our concern, however, consists of yearbooks of monasteries, so-called annals, namely annals of the Benedictine monasteries, founded in the 8th century.[2] The famous *Annales Alamannici*, for example, provides information for the years 709 through 926 for Swabia. Different annals cover different time frames (see Table 1). Some entries in annals are not original, since the respective monasteries have been founded in later centuries only (e.g., the monasteries of Weingarten, Melk and Admont). Others, namely the

[1] There is a long dispute in historiography on whether or not this chronicle was composed by one or more authors. Today, it is supposed to have been one author merely, who wrote down the chronicle shortly after y. 659, based fractional on Burgundian evidence; see Devillers and Meyers 2001.

[2] St. Gallen, founded around 720; Reichenau, founded in 724; Regensburg (Sankt Emmeram), founded in 739; Fulda, founded in 744; Rheinau, founded in 778; Xanten (Viktorstift), founded in the second half of the 8th c. Exceptions consist of Fleury (Saint-Benoît-sur-Loire), founded in 640, and Salzburg (St. Peter), founded in 696 (Fig. 1).

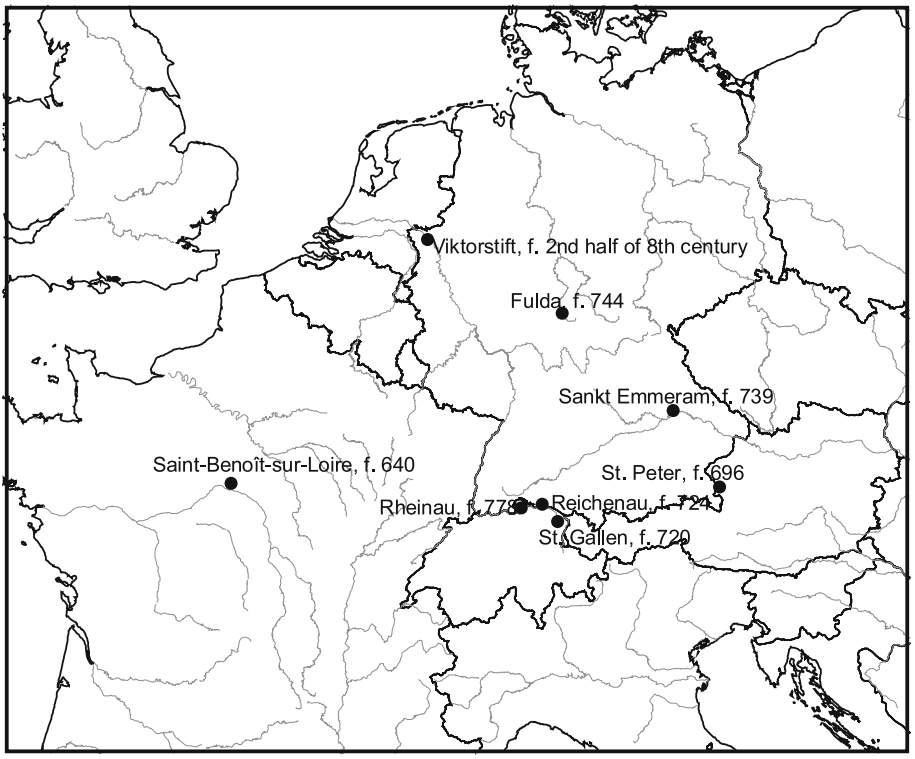

Fig. 1 Map with relevant monasteries founded between 600 and 800

Annals compiled in the *Scriptores rerum Langobardicarum et Italicarum* (1878/1964) hold no information for our purposes at all.

The structure of the discourse in annals is chronological: they present events in the sequence of their occurrence, usually providing one or two sentences for each year, without going into detail. In addition to significant political events like the coronations or deaths of kings and popes, or wars, natural disasters were often cited. Indications on whether a particular event actually found its way into such annals are unclear though. Only after A.D. 1000 do records in annals become longer. Not until the 13th century do we find any damage descriptions of earthquakes in Switzerland. White (1987) has indicated the relevance of the declaration of natural events in the annals. In fact, the yearbooks consist of shortcomings in their annual notes. Entries of one or two sentences are the rule. This furnishes the particular evidence with an even more important relevancy. Records on natural disasters can thus be taken as having been very seriously considered, especially when near monasteries. Other than annals and chronicles, a small number of written evidence exists, namely records of private matter, usually held by ecclesiastics.

For the given time and region of interest, we identified half a dozen events in the area of modern Switzerland between 849 and 954 (Table 2). This is a small number, given that one to four earthquakes are perceptible per year in the region under consideration. For our research, all written evidence at hand came under a thorough scrutiny, namely the annals of monasteries belonging to the Empire.

Table 1 Table with all relevant annals and the time period they cover

Title of annals	Time period covered by the annals (originals a/o copies)
Annales Admuntenses	From ''Abraham''–1139
Annales Alamannici. Annalium Alamannicorum Continuatio Augiensis	801–859
Annales Alamannici. Annalium Alamannicorum Continuatio Sangallensis Prima	860–876
Annales Alamannici. Annalium Alamannicorum Continuatio Sangallensis Tertia	882–912, and 926
Annales Augienses (Pars Secunda, Genuina)	860–954
Annales Bertiniani	741–882
Annales ex Annalibus Iuvavensibus antiqui excerpti	725–939
Annales Flaviniacenses et Lausonnenses, Annales Lausonnenses	841–985
Annales Floriacenses	626–1060
Annales Formoselenses	770–1136
Annales Fuldenses	680–901
Annales Mellicenses	1–1123
Annales S. Emmerammi Minores	743–1062
Annales Sancti Rudberti Salisburgenses	1–1285
Annales Sangallenses maiores	719–1056
Annales Weingartenses	708–936
Annales Xantenses	655–874
Chronique de Marius d'Avenches	455–581
Gregory of Tours, Decem Libri Historiarum	From ''creation''–572

Table 2 Table of known events of the first millennium in Switzerland

Year	Event	Main sources	Possible site of occurrence
563	Rockslide	–	Le Grammont (VS)
849, Feb. 18	Earthquake	French Annals	Burgundy; France
849, April 20	Earthquake	Annals of Reichenau; Walahfrid Strabo	Swabian Alps; Eastern Switzerland; Reichenau
867, October 9/10	Earthquake	Annales Alemannici (Monastery of Reichenau)	Bavaria; Eastern Switzerland
902	Earthquake	Annales Alemannici (Monastery of Reichenau or St. Gallen)	–
944	Earthquake	Annales Augienses (Monastery of Reichenau)	–
954	Earthquake	Annales Augienses (Monastery of Reichenau); Chronicle of Marianus Scottus	–

2 The rockslide at Tauredunum in 563

Geological and historical literature mentions a rockslide for the year 563 in the south-western part of Switzerland (Valais) (Fig. 2), an event associated with an earthquake in studies, recently by Beres et al. (2000) and Berlioz (1998), but also by Favre (1867), and others.

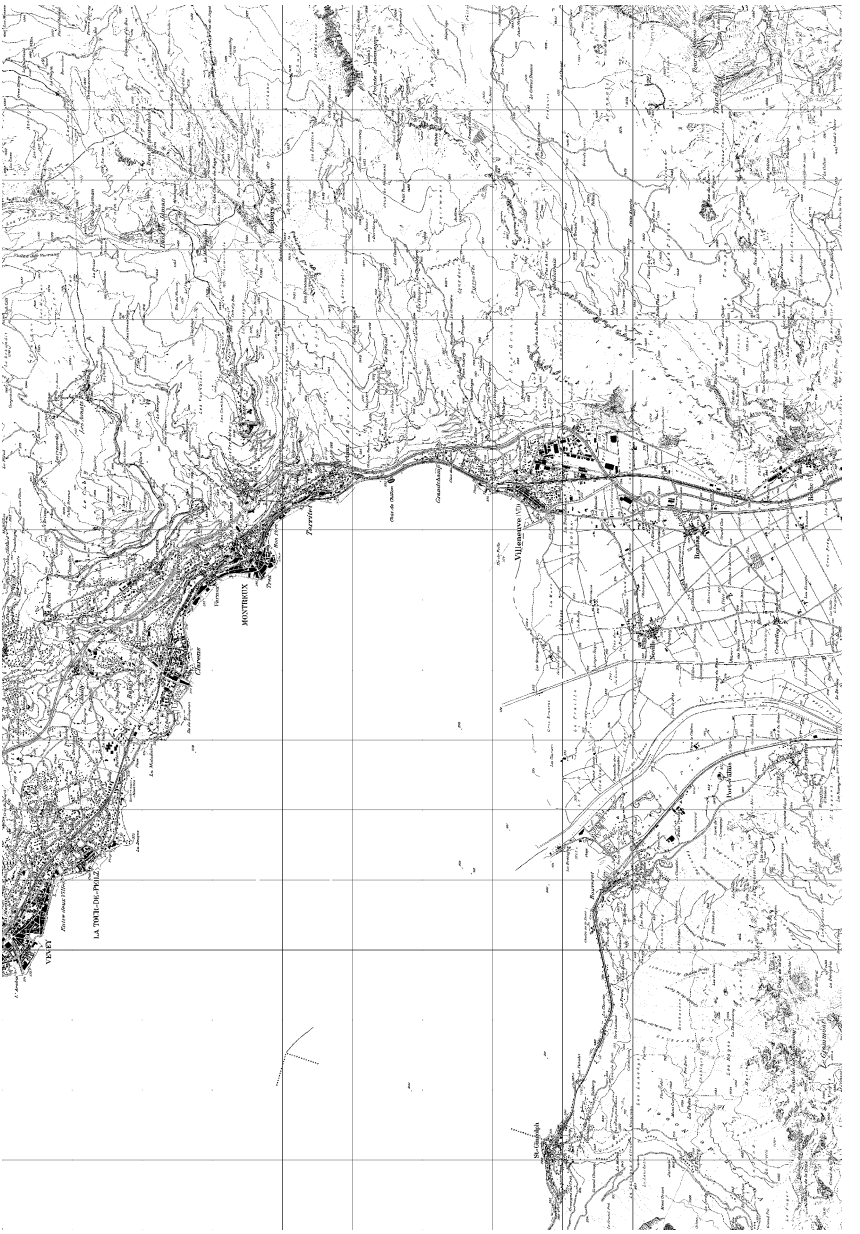

Fig. 2 Map of the site Tauredunum

This event has been passed down via two narrative records, which are considered independent. First is the already mentioned work by Gregory of Tours, his *Historia Francorum* (1937), a history of the Merovingian dynasty. Second is the chronicle by Marius d'Avenches (1991). Alexandre (1990) and Kurth (1919) consider the record of the later a copy of the annals of the ancient kingdom of Burgundy. Given the importance of evidence in these two works, we assume that this event was one of the most spectacular natural disasters of the time. Both the contemporary writers place the event in the year 563. Gregory of Tours mentions the rockslide at the *Tauredunum*, followed by a recorded solar eclipse, so the rockslide can be fixed at October 3, 563.

Geological studies tried to localize the event and determine its scale of intensity. Both contemporary authors named *Tauredunum* as the site of the occurrence; Gregory additionally mentioned a *castrum* being destroyed by the rockslide (Seylaz 1955). Since there is no modern equivalent for *Tauredunum*, an extensive discussion on its location was carried out. Howald and Meyer (1940), Bertrand and Fournier (1936), and Montandon (1925, 1933) placed it at the *Dent du Midi*, in the region of *Bois-Noir*, north of St. Maurice in the Valais, where a rockslide can be identified. Favrod (1991) questioned this by arguing that in such a case the rockslide would have affected the then very important monastery of St. Maurice, and thus left some trace in written records. This hypothesis ''ex silentio'' however, is of little help, because records for the respective period are so rare. Today, the site of the historical *Tauredunum* is assumed to be located *Le Grammont*, situated at the south-eastern coast of Lake Geneva in the Valais. In the rockslide, traces of human bones and vegetable residue have been connected to this natural disaster (Martin 1910) and thus verified the assumption that *Le Grammont* is the historical site *Tauredunum*.

Beres et al. (2000) reconsidered the hypothesis of an earthquake causing the rockslide. They suggested taking into account the incident at Tauredunum (*Le Grammont*) as a secondary effect of an earthquake that caused rockslides at several sites in the Alps as well as an inundation of Lake Geneva. Even though there is some indication for this hypothesis, geological investigations did not strongly support it. In historiography it was the historian Berlioz (1998) who brought the earthquake thesis into discussion, based on the studies of Favrod (1991) and Martin (1910). Since Berlioz did not present new documentation, his arguments remained somewhat vague (Rohr 2003).

On the location and the course of the event itself, several questions remain open. Gregory of Tours narrates the ''marvelous event at the castle of Tauredunum'' situated above the Rhone River. He tells of a roaring coming from the mountains, starting 60 days before they cracked and let loose. The rockslide was supposed to destroy several buildings and kill numerous people. The debris only stopped in the riverbed, forming a natural dam that caused inundations and shattered the nearby sites. After the event—so Gregory writes—thirty monks visited the site to dig for ore and iron. While doing so, the mountain rumbled again. The monks though, greedy in gathering the minerals, did not pay attention, and were likely killed by a subsequent rockslide.

The much shorter text by Marius notes the destruction of a *castrum* and several villages, killing all their residents. Furthermore—in contradiction to Gregory's text—the rockslide is supposed to have caused a tsunami in Lake Geneva, generating great destruction in the town as well as in nearby villages. The account of the monks, narrated by Gregory, has no correspondence in Marius' writings. Gregory's documentation, thus, seems a moral insinuation rather than a fact: the greedy monks

had to be punished for their morally false behavior through a second rockslide and so serve as a warning example. Marius' text, on the other hand, lacks any moral implications.

Pertinent for us is the question of whether an earthquake caused the rockslide. Earthquakes as such were very well known in antique and medieval literature. As Trüb (2003) has shown, Gregory of Tours mentioned eight earthquakes in his *Decem Libri Historiarum*. Yet neither Gregory's nor Marius' writings hint at earthquakes as a cause for the rockslide: We thus assumed that the rockslide was caused by another natural phenomenon and did not incorporate this event in the Swiss Earthquake catalog (Fäh et al. 2003).

3 Early middle ages

The time period between A.D. 600 and 1000, covering the early as well as the beginning of the High Middle Ages, still lacks much written evidence. Nevertheless, literary activity increased in the Rhine Region and France, if not so in Italy, which played a marginal role concerning cultural influence in this era, particularly in the 9th century. In the region of modern Switzerland, some centers blossomed after A.D. 600 due to the foundation of new monasteries by the nobility, the establishment of new villages, and an increase in population. New cultural centers with reputable authorities grew, especially in the western part of Switzerland, and after 700, under the influence of the Carolingians, in eastern Switzerland too (Reichenau and St. Gallen, Constance, Engelberg and Einsiedeln) (Keller 1973; Peyer 1980; Vogler 1995). Some of these abbeys fostered an ecclesiastical culture that generated a remarkable number of manuscripts, charters and books still available today (e.g., in the archives of St. Gallen, nowadays a UNESCO world heritage site for that reason) (Peyer 1980). Researchers benefit from this increased data.

The original documents at hand, namely annals, derive predominantly from the Lake Constance region. It is noteworthy that records of natural disasters are to be found relatively often, considering the scarcity of such manuscripts. Apart from annals, other important historical records for earthquake research are hagiographical and historiographic texts. Yet the analysis of annals—the primary source—is somewhat tricky. They were produced for the use of the abbeys, usually written anonymously, without title, preface, dedication or literary claim, and often transmitted through many hands and generations in the same archdioceses (Grundmann 1957; White 1987). Their chronological records are short but full of blanks (Fig. 3). Many of the annals are still available in their original form but an unknown number is lost and has to be traced via later copies. Annals are compilations, a fact that complicates their analysis. More often than not these books were handed over from one place to another within the same diocese; they were amended with notes and pieces of information from unknown sources (Vogler 1995). As a consequence, the relationships between annals are very complicated, as are their dependencies.

For our survey, we essentially dealt with Carolingian annals circulating among the Benedictine abbeys (Fig. 1). The events mentioned in the particular annals might have occurred in the respective region of the annals, or not. In cases where we

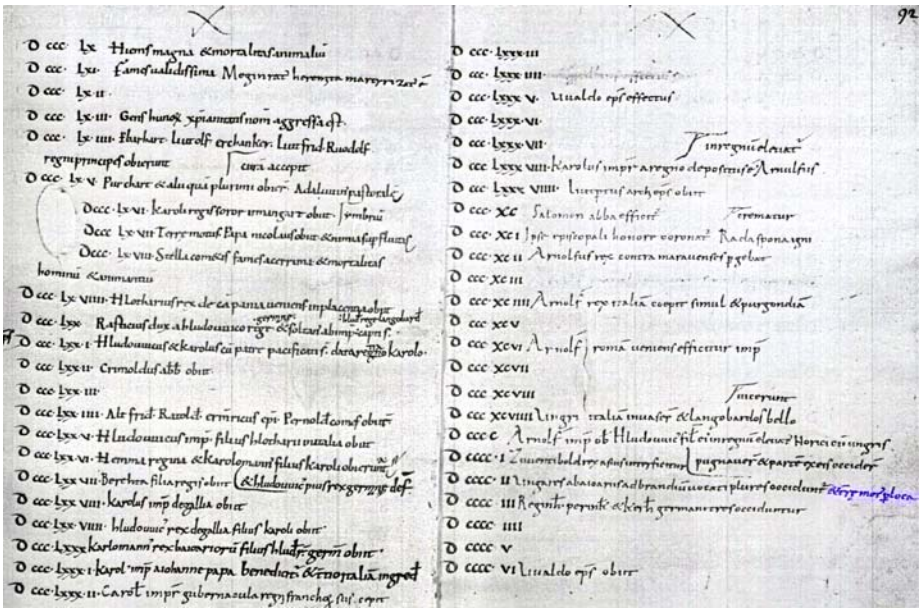

Fig. 3 Excerpt of the Annales Alemannici (Stiftarchiv St. Gallen, Zürcher Abteilung X, Urk. Nr. 1 (706–926))

managed to determine their original site of production, the annals were of a high reliability.

Both text migration and compiled information, instead of pure facts have led to misunderstandings and misinterpretations in the course of interpreting annals. A critical distinction between original and derived texts is crucial, but sometimes impossible. In addition, annals are usually available in printed versions, access to original manuscripts is often difficult, and sometimes impossible. We thus depend on critical editions. Medieval manuscripts of the German speaking regions within Europe (Germany, Austria, and Switzerland) were collected and edited in the *Monumenta Germaniae Historica* (*MGH*), established in 1819 by the Society for German History (''Gesellschaft für ältere deutsche Geschichtskunde''). Contexts of production and transmissions of the manuscripts were usually neglected in older transcripts, and have only become important in more recent studies (Lendi 1971). This increases the difficulties of a coherent text interpretation. Such frustrations challenge historical seismology, which asks for localization and date/time-classification of a particular event. A coherent investigation of the place of production of a record is sometimes difficult, but always vital for successfully localizing the event's site. Since the respective entries are rather short, they lack hints on where the event actually occurred. We have to restrict ourselves to naming the place of production rather than assuming the respective region of an event. Localization is thus determined with a huge uncertainty. The same is true for the intensity and damage field of the events in discussion. A term like *terraemotus magnus* ('vast earthquake') does not necessarily suggest the dimension of an event; on the contrary, the respective author might have preferred this term to honor the greatness of God. Parameters of the respective events were thus not provided in the catalog (date only, but no reference to place and intensity).

4 The events of the year A.D. 849

An event in the year 849 has been noted in several catalogs (Alexandre 1990; Fäh et al. 2003; Guidoboni et al., 1994; Lambert and Levret-Albaret 1996). This apparently extensive and reliable database weakens, however, when we consider its mode of production.

Many of the annals at hand mentioning the quake are only copies of contemporary annals. This is true for the famous *Annales Sangallenses maiores* (1826), copies of the *Annales Alamannici*, the latter being among the most important of the German speaking regions for the respective time (Scarpatetti 1995; Schmucki et al. 1998). The *Annales Weingartenses* (1826) go back to the *Annales Augienses* (1826), which—for the year 849—are a copy of the *Annales Alamannici* (Moser 1824). The annals of Regensburg and Salzburg are somewhat difficult to judge, as determining their origin is complex. The entry for Regensburg mentions heavy earthquakes for the years A.D. 848 through 851, without giving any specific date (Annales S. Emmerammi Minores 1881). The record in the annals of Salzburg, on the other hand, states a *Terrae motus*, but cannot be verified for authenticity (Annales ex Annalibus Iuvavensibus antiqui excerpti 1926).

The *Annales Alamannici*, on the other hand, were produced between A.D. 709 and 799 in different monasteries of Swabia and were later carried out as regional annals in the monasteries of St. Gallen and Reichenau until 926 and 939 respectively. They were followed by the distinguished *Annales Sangallenses maiores* until 1056. The record of A.D. 849 in the *Annales Alamannici* was written down in Reichenau (Lendi 1971), so we can assume with some confidence that the event was felt in Reichenau (StiASG, Annales Alemannici; StiBSG, Codex 915). This assumption can be confirmed by a second historical document, so far unconsidered in literature. The abbot of the Monastery of Reichenau and hagiographer *Walahfrid Strabo* (ca. 808–849) maintained what we nowadays would call a journal or jotter, a *Vademecum* (StiBSG, Codex 878). This memoir refers to the A.D. 849 event and even reports aftershocks (Fig. 4).

Walahfrid Strabo was a scholar, a tutor to Charles the Bald (823–877), and later abbot of the eminent monastery of Reichenau and author of a famous Gallus-Vita (Bischoff 1967; Brunhölzl 1975). His *Vademecum*, which comprises notes over a quarter century, holds entries on almost everything: trivia, need-to-know information, and all parts of a scholar's daily life, including natural observations. In the year 849 he put on record: ''Anno ab incarnatione dni. [i.e., domini] DCCCXLVIIII. Terrae / motus maximus factus est post primum gallorum / cantum XII. kal. Mais. die Saturnis et fuit [uncertain reading] / diebus: et postea per interualla tamen sepe uenit / kl. iun. ipso anno prima mane die sabbato accidit.'' ['In the year 849, a most significant earthquake occurred, after the first cockcrow, at April 20, a Saturday; and lasted several days. Others followed periodically until the first of June of the same year, early in the morning.''] (StiBSG, Codex 878). What is most intriguing is that Wahlafried set a punctuation between the first and the second parts of the entry, starting a new paragraph previous to the handwritten addendum ''et postea''. Bischoff (1967) has pointed out that this gives the record a reliably eyewitness feel. What's more, the record allows dating the event precisely as having taken place on April 20, 849 in the morning hours. The main shock was followed by several aftershocks lasting until June 1, 849. If it was perceived in Reichenau, we may assume

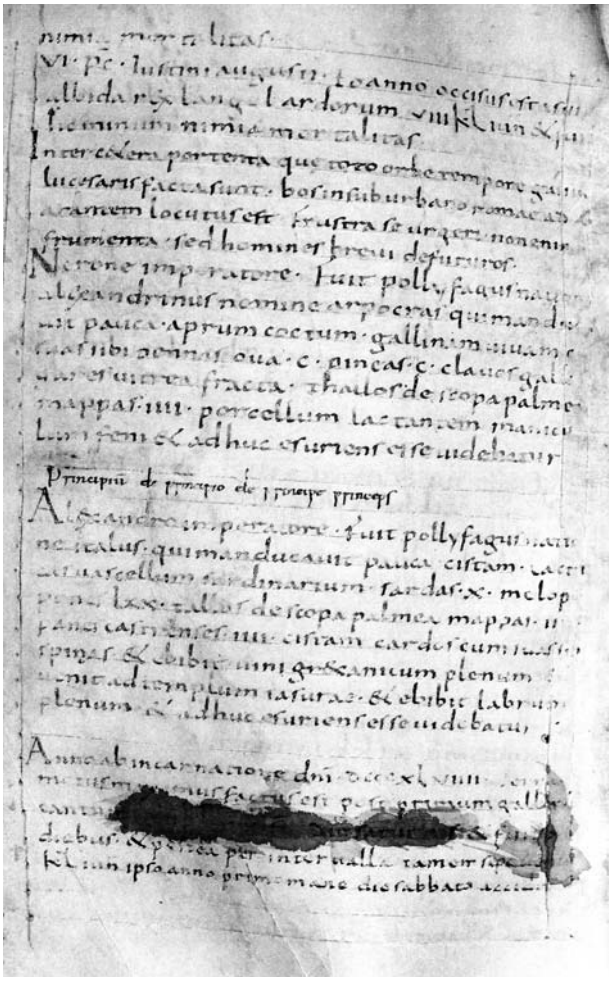

Fig. 4 Extract of the Vademecum of Walahfrid Strabo (N° 878, parchment, 394 pages, 21 × 14 cm), Monastery of Reichenau, around A.D. 825–849; mapped in Schmuki et al. 1998:59

that it was felt in the broader parts of eastern Switzerland and southern Germany. Since the main shock was followed by several aftershocks, we think that the event was a powerful earthquake.

Additional annals providing hints of an earthquake in the year 849 are at hand (Fig. 5). They were produced in the western part of Switzerland and in France: the *Annales Flaviniacenses et Lausonnenses* (1839), produced at that time at Lausanne (CH),[3] the *Annales Floriacenses* (1829), produced in Fleury,[4] the *Annales Bertiniani*

[3] "849. Terrae motus fit 12. Kal. Martii. in omni terra. [February 18, 849, an earthquake occurred on the entire globe]".

[4] "849. Anno 8. Karoli regis, 12. Kal. Martii extitit terraemotus quasi decima hora noctis. [849. In the eighth year of the government of Charles, on February 18, an earthquake occurred at the tenth hour of the night (i.e., between 5 and 6 AM., as the counting of the hours starts at sunrise and sunset, respectively)"].

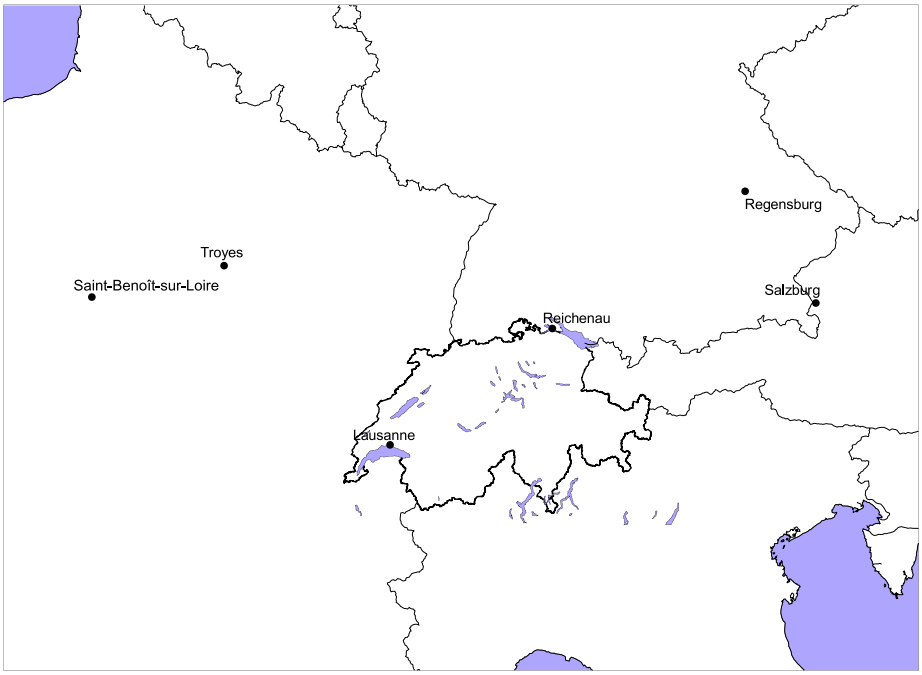

Fig. 5 Map of written evidence for the year A.D. 849

(1826), for the time given produced in Troyes (F),[5] and the *Annales Formoselenses* (1844), a copy of the *Annales Alamannici*. All of them provide the same hour as in the example above, and a day that—in terms of Latin dating—looks very similar to the date given by Walahfrid; however, they note a dissimilar date of month (12. Kal. Martii = February 18). Since both pieces of information provide resemblances as to hour and day, it might be reasonable to consider one event, transferred by the entries in the French annals as an error in transmission. In fact, it is quite feasible that the records of the Eastern annals wandered into their French counterparts, since the Carolingian monasteries maintained complex affiliations all over Europe. However, since the annals comprise completely different text corpuses, we prefer to assume the occurrence of two events: the first on February 18, 849 (felt in Burgundy and France); the second on April 20, 849 (felt at Reichenau).

Yet, where was the potential epicenter of the April 849 quake? There is little indication to place it in the Basel area, since this region has been thoroughly investigated by paleoseismological studies (Becker 2002). A strong event would have left traces in quaternary sediments or instabilities of lake sediments in Lake Lucerne and Lake Zurich, neither of which shows any evidence for a large earthquake for that time (Monecke et al. 2004; Strasser et al. 2006). This is also true for any epicenter in central Switzerland. Leaving the French documentation aside, it is more

[5] "849. [...] Apud Galliam 13. Kal. Martii, nocte sequenti clericis nocturnas preces Domino solventibus, terrae motus valide sed nulla quorumlibet aedificiorum ruina factus est. [...]. [849. In Gaul [France], the night after February 17, whilst the clerics provided God their prayers, a vast earthquake occurred; without evoking any damage.]"

probable to locate the epicenter in the Swabian Alps (Schwäbische Alp), Eastern Switzerland (Mittlerer Rheingraben), or even close by Reichenau, where aftershocks were reported. These hypotheses however, remain speculative.

5 The event of October 9/10, A.D. 867

Twenty years later, another earthquake occurred in our region. The *Annales Alamannici* (StiASG, Annales Alemannici) are yet again the most important historical records: ''DCCCLXVII. Terre motus.'' ['867. Earthquake'']. In the years A.D. 802 through 876, the *Annales Alamannici* were compiled in the monastery of Reichenau, and we thus assume the quake to have occurred in that region (Lendi 1971).

Furthermore, the event was passed down via several annals, though many are copies of the *Annales Alamannici*, some of them presumably secondary or tertiary replica (Fig. 6). The *Annales Weingartenses* (1826)[6] as well as the *Annales Sangallenses maiores* (1826)[7] are reproductions of the *Annales Alamannici*. Authentic entries are provided in the *Annales Xantenses* (1829)[8] as well as in the *Annales S. Emmerammi Minores* (1881).[9] The *Annales Fuldenses* (1826), deriving from Fulda, were at the time given supposedly composed in Mainz.[10] The *Annales Sancti Rudberti Salisburgenses* (1851) as well as the *Annales Admuntenses* (1851) are not genuine; but are based on the *Annales Mellicenses* (1851). Their entries for the year A.D. 867 copy the *Annales Regni Francorum* as well as the *Annales Alamannici* and are thus not considered (Alexandre 1990). The same is true for a chronicle of the 11th century (Herimanni Augiensis Chronicon, 1844). The event has hence been passed down originally in German regions. The event can either be considered a German earthquake or an event of eastern or central Switzerland.

6 The events of the tenth century

For the last century of the first millennium, we distinguish three earthquakes, apparently having occurred in Switzerland. All were passed down via local annals only in the *Annales Alamannici* and the *Annales Sangallenses maiores*. Records in other annals are not genuine.

6.1 902

The *Annales Alamannici* yet again substantiate an event at the beginning of the century: ''902. [...] Et terrae motus per loca.'' [''Earthquakes here and there.''] (StiASG, Annales Alamannici). The site of production of this record is difficult to ascertain. Lendi (1971) cannot decide whether St. Gallen or Reichenau was the place

[6] ''867. Terrae motus. [...]''.

[7] ''867. Terre motus; [...]''.

[8] ''867. Terrae motus magnus [...]''.

[9] ''865 [amended: 867]. Terrae motus fuit.''

[10] ''867. [...]. Terrae motus per plurima loca factus 7. Id. Octobris. [October 9, 867, an earthquake occurred at several sites]''.

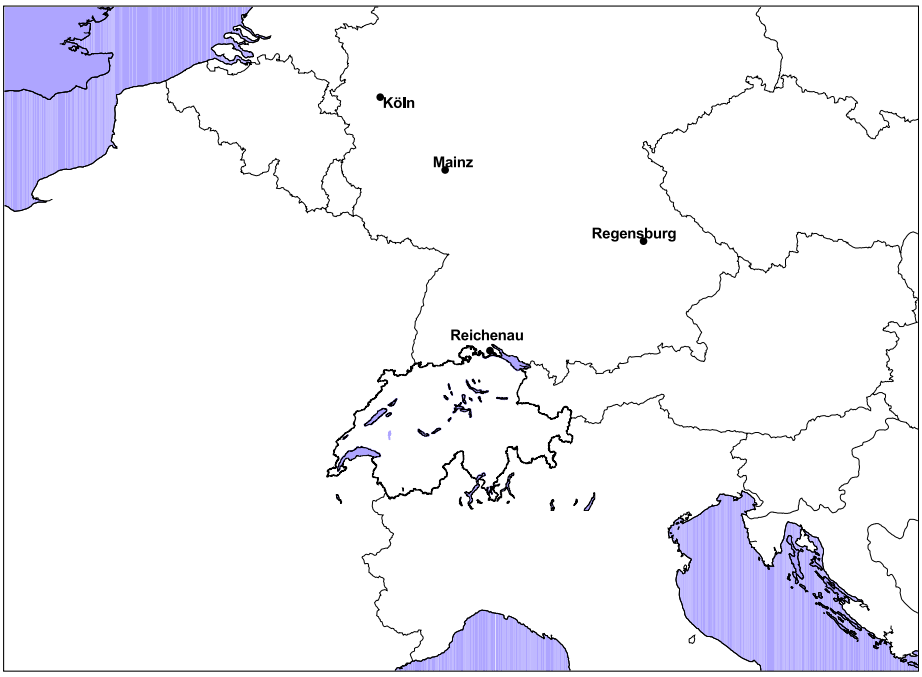

Fig. 6 Map of written evidence for the year A.D. 867

of origin. The *Annales Sangallenses Maiores* (1826) are again copies of the *Annales Alamannici*, and are thus not to be taken into consideration. Whether or not we can assume this event, as local is difficult to conclude.

6.2 April 16, 944

For this event, the entry of the *Annales Sangallenses maiores* (1826) can be considered authentic. Records are somewhat more elaborate at the time, yet no location is provided: ''Terrae motus factus est 3. feria paschae circa pullorum cantum 16. Kal. Maii.'' [''April 16, 944, Tuesday after Easter, an earthquake occurred, at the time of the cockcrow.'']. Pertz (1826) considers this entry as being originally from St. Gallen. We thus parameterized the event for April 16, 944, early in the morning, most likely having hit the region of St. Gallen. Other annals such as the ones of Admunt and Salzburg and Melk are copies of the *Annales Augienses*, and are hence not relevant for our interpretation (Alexandre 1990). Parameters of the event cannot be determined.

6.3 954

The *Annales Augienses* (1826) mention an earthquake for the year 954, occurring at several sites in Germany and Gaul: ''Per loca Germaniae Galliaeque plurima terrae motus magnus factus est.'' [''A vast earthquake occurred at several sites in Germany and Gaul.'']. Pertz (1826) suggests that we consider the entries in the *Annales*

Augienses after 860 as from Reichenau. We thus assume this event to have hit eastern Switzerland. The *Annales Sangallenses maiores* do not mention the event.

An entry in the chronicle of Marianus Scottus (1028–1082) (Marianus Scottus 1844) is supposed to note this event. The record is genuine for Mainz, where Wilhelm, Archbishop of Mainz (954–968), resumed the *Annales Augienses* (1826). Due to an individual counting of the years, Marianus reports an earthquake in the year 974. Both Guidoboni (1989) and Alexandre (1990) adjusted the given year of the event to 952. Yet the wording of Marianus equals the entry in the *Annales Augiensis*: ''974. Per loca Germaniae Galliaeque plurima terrae motus magni facti sunt.'' In contrast with Guidoboni (1989) and Alexandre (1990), we recommend considering these two entries (in Marianus Scottus 1844, and Annales Augienses 1826) as marking one event of the year 954. The question of whether the event struck Switzerland, however, remains open.

7 Conclusions

Evaluating possible earthquakes within the territory of modern Switzerland before the year 1000 is made difficult without enough reliable, detailed data. Written records for the first half of the first millennium A.D. are scarce: there is little hope of finding any written proof for earthquakes (Drack and Fellmann 1988; Howald and Meyer 1940). Currently, we have knowledge of only six earthquakes within this period. A possible earthquake of A.D. 250 in *Augusta Raurica* relies on archeological evidence alone. For the sixth century *Gregory of Tours* gives hints in his *Historia Francorum* of a rockslide near the castle *Tauredunum* in the Swiss canton Valais, causing an inundation of Lake Geneva. Geological investigations did not prove an earthquake as the trigger for the rockslide.

The period of the *Carolingians* (ca. 750–950) included the rise of some very important cultural centers. In several parts of modern Switzerland (Reichenau, St. Gallen, Engelberg, Einsiedeln, St. Maurice, etc.) ecclesiastic culture blossomed. In St. Gallen, written records were produced in a unique manner and have survived. This cannot be said for Reichenau, where very few records remained, and even less for the regions of Graubünden (Rätia), Zurich, Rheinau, Moutier etc. For St. Maurice almost no written documents survived (Peyer 1980). Earthquakes occurring in that area, start to be recorded after the year 800.

In the ninth and tenth centuries, written evidence is given for six seismic phenomena in A.D. 849 (two earthquakes), 867, 902, 944, and 954. Reference to such events comes mainly from annals, which provided little information. Locations and intensity are scarcely to assess. Other source types exist in only small numbers. The *Vademecum* of the abbot and hagiographer *Walahfrid Strabo* (ca. 808–849) is one of these rare examples. For an event in the year 849 he provides the event's date and time of day and gives hints of aftershocks. Given the respective date and location, we propose that an early morning event took place on April 20, 849.

Records in French annals mention another earthquake in the same year. It is possible that entries in the Eastern annals wandered into their French counterparts, since the Carolingian monasteries maintained complex affiliations all over Europe. However, we assume the occurrence of two large events: the first one in (parts of)

France on February 18, 849; the second one in southern Germany (Swabian Alps) or eastern Switzerland (Mittlerer Rheingraben) on April 20, 849.

Several open questions remain. In historical seismology we need to know more about an earthquake than its mere occurrence. Since records in annals seldom refer to the place of an event, determining location has to remain open or approximate. Moreover, determining damage can hardly ever be specific. Catalog entries are thus to be carried out with reluctance and a large uncertainty factor. For the reasons given, location and intensity parameterization were not determined in the Earthquake Catalog of Switzerland (Fäh et al. 2003). We can indicate only tentative conclusions on Swiss earthquakes and natural disasters in the first millennium.

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